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ABSTRACT

The purpose, audience, methodology, and statistics of classroom utilization reports used at the University of Colorado, Boulder, are examined with a view toward an evolving report on a schedule of classes. Utilization reports from the past decade are examined in terms of information attributes discussed by Kleijnen (1980). A computer-generated report is described that emphasizes the use of bar charts, plots, box plots, coded tables, and other semi-graphic displays. End-user computer programming languages such as SAS (Statistical Analysis System) make it possible to use the information that went into classroom utilization reports for current purposes. A change in purpose of a classroom utilization report raises issues of timing, accuracy, and scope, while a change in the audience raises questions of timeliness, report mode, aggregation, confidentiality, and scope. Attention is focused on the needs of middle management, which require reports that are germane to the issues of the day but are also timely. Changes in the reporting methodology raise issues in regard to timeliness, accuracy, and flexibility. For planning it is important to have the flexibility to answer new questions, and flexibility depends on the level of the language used for the report. The new report on the schedule of classes developed at the University of Colorado focuses on data quality in three ways: by listing data that is likely to be erroneous (e.g., an arranged course with 30 students enrolled); by using robust statistical methods and displays (e.g., reporting the medians and by using box plots); and by supporting summaries with detail that makes the report auditable. A page from the spring 1982 schedule of classes report and an adaptation of Tukey's stem-and-leaf display, along with a bibliography, are appended. (SW)

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BRINGING CLASSROOM UTILIZATION REPORTING UP-TO-DATE

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THE ASSOCIATION FOR INSTITUTIONAL RESEARCH

This paper was presented at the Twenty-Second Annual Forum of the Association for Institutional Research held at the Denver Hilton Hotel in Denver, Colorado, May 16-19, 1982. This paper was reviewed by the AIR Forum Publications Committee and was judged to be of high quality and of interest to others concerned with the research of higher education. It has therefore been selected to be included in the ERIC Collection of Forum papers.

D. R. Coleman, Chairman
Forum Publication
Advisory Committee

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ABSTRACT

The purpose, audience, methodology and statistics of classroom utilization reports are examined with a view toward an evolving report on a schedule of classes. Utilization reports from the past decade are examined in terms of information attributes discussed by Kleijnen (1980). A computer generated report is described which emphasizes the use of bar charts, plots, box plots, coded tables, and other semi-graphic displays. Issues such as data quality, timeliness, and the use of SAS are discussed.

INTRODUCTION AND PERSPECTIVE

Because enrollments in higher education today are stable or declining, classroom utilization studies do not serve institutional growth as they once did. However, end-user computer programming languages such as SAS (Statistical Analysis System) make it possible to use the information that went into classroom utilization reports for current purposes. With the evolution of a classroom utilization report's purpose, intended audience, handling of data, methodology, and statistics, it deserves a new label: a schedule of classes report. This paper is a report on work-in-progress at the University of Colorado, Boulder and a discussion of some of the motives behind and problems ahead of a schedule of classes report.

Reporting on classroom utilization has long been closely linked to the construction of new academic buildings. For example, Dahnke, Jones, Mason and Romney (1971) observe:

> Much, but not all of the impetus for a typical utilization study has come from extrainstitutional sources, such as federal and state legislative bodies, education coordinating councils, foundations, and state budgeting offices. All have been asked to support the expenditures of capital dollars for more college and university buildings.
>
> [emphasis added]

As a result of the purpose and extrainstitutional audience of such reports, calculated capacity of instructional facilities is the principal yardstick and the critical questions have been: "when will (or when did) need outstrip capacity?" and "is the need for more capacity real or only apparent (i.e., due to 'inefficiency')?" Efficient classroom utilization is an attractive issue to some because it seems more concrete and more easy to measure than most other outcomes or conditions in higher education. Russell and Doi (1957, p. 35)

imply an even closer connection between utilization studies and new construction: "The exact frequency interval for repeating the [classroom utilization] study would be dependent on such factors as rate of enrollment change and additions to the plant." This paper argues that studying classroom utilization, once a technical step in the process of justifying new construction, today should be a part of a more comprehensive examination of the schedule of classes. For facilities planners, a report on the schedule of classes must provide a more detailed but easier to use description of instructional needs and utilization patterns than was previously available, since space trades and renovations seem more politically delicate than new construction projects. The schedule of classes can reveal problems and opportunities in the budget or curriculum as well as in facilities.

Whether the traditional audience (funding agencies) is to be addressed or not, a significant internal audience needs to know about the relationship between the schedule of classes and a variety of constraints. Although many utilization reports (e.g., Hunt, Tyler and Sears, 1979) would protest to the contrary, utilization reporting as traditionally practiced can not improve utilization. As pointed out in Ohio Board of Regents (1975), improved utilization depends "more upon the number and sizes of rooms and courses, and not upon the method of assigning one to the other." According to Temmer's (1972) account, good horizontal communications between a variety of individuals and agencies involved in the development of the schedule very much affects utilization, but retrospective utilization reporting does not. A major goal of the University of Colorado's sschedule of classes report is to provide a common basis for discussions among a diverse group, including deans, the registrar's staff, facilities planners and other administrators about facilities and scheduling constraints, the scheduling process itself and a variety of

issues incidental to scheduled instruction. Ancillary reports addressing specific issues have been developed as a result of the schedule of classes report. Such ad hoc reports provide the opportunity to experiment with ideas that can subsequently be incorporated into a main report or might have a specific place in the planning cycle. A larger audience tends to improve the accuracy of a report: to generate enough effort to improve the quality of the data requires the help of individuals for whom facilities-related issues may be of secondary concern. From a facilities planner's perspective this is reason enough to involve a larger audience. Although facilities planners tend habitually to think in terms of rooms and buildings, when thinking about planning the schedule of classes the natural unit of thought is the course and the academic department. Rockart (1979) discusses the problems of understanding the information needs of others.

Another factor which has affected classroom utilization reports is methodological. Writing in 1957, Russell and Doi assume a manual method of preparing utilization reports by providing data gathering and analysis forms that an institution can adapt and then fill out. Most of the utilization reports reviewed in this paper appear to be derived directly from Russell and Doi. Although the computer may appear to reproduce the same report with less labor, unanticipated side-effects normally occur. Manual preparation of a report accomplishes a great deal of intuitive data screening and editing and provides a natural check on report bulk. Exploiting the full potential of the computer depends at least in part on dealing with issues of data quality, bulk, and flexibnility. Flexibility is a fundamental issue in this context not only because the part of the world being reported on by a computer-generated report changes but also because a good report changes part of the world by affecting the views and knowledge of its readers. If the report can't

change to reflect increasing sophistication or changing interests it is soon regarded as irrelevant or, worse, as a perceptual obstacle.

SAS has proved to be an ideal tool for the kind of reporting being discussed in this paper for several reasons. First, it can access and aggregate to the appropriate level all of the data necessary for the report. Second, its data editing and management facilities make preparation of the data easy and keep the house-keeping-chores aspect of a large project within reason. Third, its information display facilities are comprehensive, including standardized listings, charts, plots, or boxplots and specialized displays such as coded tables or modified stem-and-leaf displays which require the flexibility of a high-level programming language (see Smith 1982). Finally, SAS is so easy to use that one personb can be responsable for the technical intricacies of accessing the data and the rhetorical issues of understanding the users of a report. SAS is easy enough to use that it encourages experimentation.

The style and content of traditional utilization reports suggest vertical communication, that is, communication aimed at a funding agency, through a governing board, from administrators and technical staff. The statistical measures in such reports seem to be designed to measure the relationship between need and capacity, and to make comparisons possible between institutions or between different times (e.g., before and after construction). Negotiating a schedule of classes is an unusually complex and participative process which depends on a wide variety of institutional information, even for an institution of higher education (see Smith, 1980). Not surprisingly, people playing different roles see the schedule of classes from entirely different perspectives. A hard look at the numbers, tables, and displays in the traditional classroom utilization report is necessary both because of a more

complex audience that is on the whole much closer to the subject and because of the opportunities or problems of using a computer. Tukey (1972 and 1977) provides many heuristic examples by sharing what he finds satisfies him in the exploration and display of data. His examples frequently seem to fly in the face of tradition, but are quite well-motivated in the literature. Tukey argues that "the computer has now made the separation [between the conventional graph and the conventional table] unbearable." Explaining to people how to extract information from displays derived rom Tukey is not difficult. The University of Colorado's report on the schedule of classes is an essay in the robustification of standardized reports and the adaptation of semi-graphic displays to an organizational process.

LITERATURE REVIEW

There are two parts to the literature on classroom utilization: conceptual treatments and actual examples of utilization studies. The major conceptual treatments are Russell and Doi (1957) and Dahnke et al. (1971), and Halstead, (1973). Their conceptual frameworks are firmly rooted in growing institutions with expanding enrollments. Of course, they provide little on issues related to the use of computers for classroom utilization reporting. As shown by the number of bibliographies in Kleijnen (1980), the literature on information systems and report design is vast.

The examination of actual examples of classroom utilization reports arose from the idea that innovations might be occurring in practice as new problems are confronted, but without the large-scale effort represented by the a conceptual treatment. A search of the ERIC (Educational Resource Information Center) database for classroom utilization reports produced in the last decade turned up several examples. These are discussed and described below, along with a report from the University of Colorado which has now been replaced.

The principal authors of the studies found in this search are typically in the institutional research office of the institution. About half are from junior or community colleges. The sample is biased since classroom utilization reports are sometimes considered sensitive and ERIC provides free access. Unfortunately, we cannot view them au naturel, clothed with the executive summaries and cover letters that are normal.

The purpose of the classroom utilization reports found in this search seems to be exactly as one would expect from conceptual tratments such as Rusell and Doi (1957). Sometimes there is a notable vagueness of purpose, as in Hunt (1979), who states that, "among community college administrators, the use of this [classroom utilization] information for planning and budgeting has limitless implications." Still the only concrete use that is mentioned is the request for more space from a funding agency. There is no indication of how instructional space or the schedule of classes are managed, or how a utilization report might actually fit in with the mechanics of the management process.

The audience for these reports typically appears to be a single funding agency. Carter (1977) is the only one who recognizes the importance of an internal audience, where she argues that a major shortcoming of the "elaborate space planning procedures outlined in most of the state planning guides [is that they] provide virtually no information to the space users within the institution." It is not clear how, in her view, the procedure is to be improved.

Great precision and manual methods characterize many of these classroom utilization reports—another indication that these reports are ad hoc and are not to be produced regularly. Kalamazoo Valley Community College (1979), for example verified all the computerized data against manual files,

and Breen (1978) states "each [program administrator] attested to the accuracy of the data for a particular unit as of a given date." A COBOL classroom utilization report which was used at the University of Colorado during the last decade was a faithful computerization of Russell and Doi. Unfortunately, it printed pages and pages of impossible-to-read 'rejected records', it was immense, and it was impossible to verify the data or the summaries it provided. Finally it was unchangeable and seemed never to provide exactly what was needed.

Report after report gives room utilization rate, station utilization rate, and some other efficiency or utility measures, with some variation in the method of calculation. Throughout the classroom utilization reports examined, the display of information was uniformly poor. The only attempt at graphic communication is found in the time maps in Illinois Community College Board (1976), which could be made much more useful.

A quote from Kalamazoo Valley Community College (1979) might sum up classroom utilization reporting in the Seventies: "A conversation with the Macomb [County Community College] project manager revealed that [utilization] standards have not been established, data reliability problems still exist, no changes were made based on study findings, and the investigation has not been repeated."

DISCUSSION: DATA ATTRIBUTES

As a result of the changes in purpose, audience, methodology, and statistics, the data should be viewed differently. These changes are perhaps interesting in themselves and certainly important to consider in the context of report design. The following discussion examines these changes using the categorization of data attributes described by Kleijnen (1980). To review the changes being discussed in this paper:

1. Purpose. The greater importance of management issues as opposed to growth of instructional space; instructional space is regarded as one of several constraints on the schedule of classes.
2. Audience. The consequent change from an external audience concerned with inter-institution comparisons to a diverse internal audience concerned with administrative issues.
3. Methodology. The opportunities and constraints that result from the availability of end-user programming languages like SAS, helps bring the information user closer to the data—with graphics, with less effort, and with the possibility of asking new questions.
4. Statistics. The numbers, tables, words, or graphs used to describe the schedule must be appropriate for the report's purpose and audience.

Although our view of the data attributes has changed, the data elements involved are much the same as they were 25 years ago. The data elements typically necessary to prepare a classroom utilization report include the following:

- Facilities—building and room identification, square feet, actual stations, designated use, whether locally or centrally scheduled;
- Courses—department, number, section, meeting time and place, method of instruction, title, etc.;
- Students—course registration, credit hours for variable credit.

All of these elements would have been used to prepare Russell and Doi's Form A (1957, p. 59). Additional elements might be necessary to connect cross-listed courses or courses that must be taken together.

A change in purpose of a classroom utilization report raises issues of timing, accuracy and scope. If reporting on the schedule of classes is more closely associated with the planning and evaluation of each semester's sche-

dule rather than with the longer cycles associated with capital construction, reports must be more frequent, be timed more precisely, and correspond to the different phases of schedule development. (That is, a retrospective or prospective view: in terms of report design it matters a great deal whether the question being addressed is "how well did we do?" or whether it is "what do we need to know in order to do well?" The latter probably includes the former.) Since the timing of the report is more critical, the preparation of the data must be accelerated, which raises the problem of accuracy. Editing the course information file for official reports takes 6 months at the University of Colorado, which makes the official edited data practically useless for the planning and evaluation function. Consequently, the question of whether the planning process can afford to wait for 'reporting quality' data must be addressed. Exposing questionable data (such as "arranged" courses with more than 10 students registered), to an internal audience may be the main strategy in improving the quality of the data. From the perspective of a funding agency, the restriction f a classroom utilization report to capital funding issues is logical, but from an administrative perspective facilities questions must be considered in the context of operating decisions. Additional kinds of data, which might eventually be part of a schedule of classes report are:

- Faculty--salary, type of support, percent non-institutional support, etc.
- Department--total budget, target student credit hours?
- Program--course prerequisites, corequisites, anticipated frequency.

A change in the audience raises questions of timeliness, report mode, aggregation, confidentiality, and scope. Kleijnen (1980) points out the differences between top, middle, and supervisory managers regarding the frequency of reports they need: top management requires irregular reports,

middle management requires periodic, scheduled reports, and supervisory personnel tend to need real-time reporting. In contrast, the predictability of the information needs of supervisory personnel is much greater than the other two. This paper focuses on the needs of 'middle management', which needs reports that are germane to the issues of the day but are also timely. A different level of aggregation is appropriate for 'middle management', ho can tolerate, interpret and, often, do something about details in context which would be distracting for another audience. An internal report should focus on things that might not be appropriate in public, although for a public institution all of the data is in the public domain. The information requirements of an extrainstitutional audience are frequently fixed by tradition or described in guidelines. An internal audience, however, may be more difficult to satisfy because information requirements evolve more quickly. An internal audience sees connections between things which may not seem related to an external audience, and the scope of a regular report tends to follow these interconnections when possible. At the University of Colorado, our second report on the schedule of classes (Spring '82) focuses closely on conformity to a modular schedule, which emerged as an issue from discussions about the first report with this expanded audience.

Changes in the reporting methodology raise issues in regards to timeliness, accuracy, and flexibility. Manual preparation of a report on the schedule of classes for a large institution is not feasible today. Preliminary data must be used in order to complete the report on the schedule of classes in time for it to be of any use in planning future schedules. Thus we are forced into a battle against bad data. We use a table of aliases for room numbers because of the variety of ways that departments can "spell" a room number. Some of the quandaries that must be faced regarding bad data have

the character of a Zen koan. The data flow diagram on page 13 in Illinois Community College Board (1979), for example, is laughably over-simplified. For planning it's more important to have the flexiblity to answer new questions than it is to have instant answers to predetermined and narrow questions. Flexibility depends entirely on the level of the language used for the report. There is an important distinction between transaction processing aspect of data processing and the perceptual function. Efficiency is the main virtue in the case of the former, but flexibility is fundamental to the latter.

Changes in the statistics of a report raises issues of accuracy, aggregation, and scope. One clarification that results from a change in the name of the report is that most utilization reports are actually reports on scheduled use, and would look quite different if all of the irregularities of absent or visiting students, re-scheduled classes or casual, unscheduled use were reported on. Errors cannot be found until a human being thinks about the data. Some errors can be anticipated but others not. Computer algorithms can be designed to look for anticipated errors. The general approach to the display of information should be to include enough redundancy to ehlp us stumble over un-anticipated errors. The new report on the schedule of classes which we have developed at the University of Colorado focuses on data quality in three ways: by listing data that is likely to be erroneous (e.g., an arranged course with 30 students enrolled); by using robust statistical methods and displays (e.g., reporting the medians and by using box plots, see Smith, 1982); and by supporting summaries with detail that makes the report auditable (e.g., including the actual courses scheduled in a room on the detail page for each room, allowing for verification of a number of summaries). A significant change in the statistics is the possibility of many different levels

of aggregation. Aggregation can occur along several dimensions: time (hour of the day, day of the week, hour of the week, semester, conforming, day/evening), space (room, room type, number of stations), or organization (department, level of course, mode of instruction, arranged/scheduled). What is most desirable about the traditional statistics is that they are additive (i.e. the weighted mean of a group of means is a mean—there is no equivalent in the case of medians). For an internal report, deviations from an average are more relevant than an overall average. With the facilities of SAS, we can easily report on the elements that went into those statistics: much more detail is desirable because of the audience and much more detail is manageable because of displays like box plots. See Smith (1982) for a discussion of the problems and opportunities of using Tukey's graphic and semi-graphic displays in this type of report. Innovative experimentation with simple computer generated graphics is probably more likely to be fruitful at this point than careful comparisons between graphical and tabular representations of data as in Lucas (1981).

DISCUSSION: EXHIBITS

Exhibit 1 shows a page from the Spring '82 schedule of classes report. Its form corresponds closely with the traditional format for a classroom utilization report, so that most of the items on the page should be self-explanatory. What is most significant from the perspective of computerizing a large and complex report is the presence of redundant information. For example, a significant error has been made in the calculation of summary statistics. The error can be detected because of redundant information and can easily be corrected in a subsequent report because it is generated by SAS. Notice also the asterisks in some of the course numbers; as a result of the first report it became evident that classes that do not conform to a

modular schedule leave blocks of time that are not usable by other modularly scheduled classes; the asterisk was inserted to flag non-conforming classes.

Exhibit 2 is our first try at developing a planning tool to give an overview of a department's schedule. It is an adaptation of Tukey's stem-and-leaf display, where each section of a course is a leaf (across the page) and each course is a separate stem (down the page). Across corresponds to the question of how many students will be able to take a course, and down corresponds to how many different courses will be offered. The stem is made up of a title and a course number. Each leaf has three parts: 1) the number of students who took the course last time (Spring '82 data would be used for planning Spring '83); 2) a code that indicates whether the course conformed to the modular schedule (see the second title for a key); and 3) the section number. For example, the first course shown is Geology 101, section 100; preliminary data showed 160 students scheduled to meet Mon/Wed/Fri for 50 minutes beginning on the hour. To the right on the same line are shown six labs which, typically, do not conform to the modular schedule. This display was developed in hopes of providing an overview of a department's schedule with just enough detail to get at some important trade-offs. Since it took very little time to adapt this display from one which was developed to show geographic spread of a department's courses, fine-tuning, with the help of the ultimate users, should not be difficult.

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BUS 000353 D E T A I L L I S T I N G A N D S U M M A R Y S T A T I S T I C S B Y R O O M

BUS BUSINESS ROOM 000353

D E S I G N A T I O N
USE: REG CLASSROOM

USER: CENTRAL SCHEDULNG

S I Z E
751 SQ. FT.
51 STATIONS

P R O G R A M C L A S S I F I C A T I O N
100 % GENERAL ACADEMIC INSTRUCTION

U S E S T A T I S T I C S

	DAY	EVE	TOTAL
SCHEDULED HOURS	34	5	39

	STUDENT COUNT	PERCENT OF STATIONS
SMALLEST	30	58.8 %
AVERAGE	40	78.9 %
LARGEST	48	94.1 %

STUDENT STATION PERIODS OCCUPIED

MAXIMUM	2,295
CCHE GUIDELINE	1,530
DAYTIME	1,354
EVENING	207
TOTAL	1,562

S T U D E N T C O U N T B Y T I M E & D A Y O F W E E K

	MON	TUE	WED	THU	FRI	SAT	SUN
7:00 -							
7:30 -	42	47	42	47	42		
8:30 -	42	47	42	47	42		
9:00 -	30	47	30	47	30		
9:30 -	30	37	30	37	30		
10:00 -	47	37	47	37	47		
10:30 -	47	37	47	37	47		
11:00 -	45	48	45	48	45		
11:30 -	45	48	45	48	45		
NOON 12:00 -	42	48	36	48			
12:30 -	42	36	36	36			
1:00 -	42	36	36	36			
1:30 -	42	36	36	36			
2:00 -	42	44	36	44			
2:30 -	42	44	36	44			
3:00 -	39	44		44			
3:30 -	39	31		31			
4:00 -	39	31	38	31			
4:30 -	39	31	38	31			
5:00 -	39		38				
6:00 -			38				
7:00 -	42						
8:00 -	42						
9:00 -	42						

EXHIBIT 1

******** C O U R S E L I S T I N G ********

DEPT	COURSE	START	DAYS	COUNT	TITLE
ACCT	480*001	19:00	M	38	ACCT-GOVT/NONPRFT ORG
ACCT	580*001	19:00	M	4	ACCT-GOVT/NONPRFT ORG
B AD	450*001	12:00	M	42	CASES-CONCEPTS BUS POL
B AD	450*005	12:00	W	36	CASES-CONCEPTS BUS POL
B AD	450*006	16:00	W	38	CASES-CONCEPTS BUS POL
B AD	450*007	15:00	M	39	CASES-CONCEPTS BUS POL
B L	300 007	11:00	T T	48	BUSINESS LAW
FIN	305 006	14:00	T T	44	BASIC FINANCE
FIN	401 002	9:30	T T	37	BUSINESS FINANCE 1
FIN	402 003	12:30	T T	36	BUSINESS FINANCE 2
PRMG	300 001	8:00	M W F	42	PROD & OPER MANAGEMENT
PRMG	300 005	8:00	T T	47	PROD & OPER MANAGEMENT
R ES	300 001	10:00	M W F	47	PRIN OF REAL ESTATE
R ES	300 002	11:00	M W F	45	PRIN OF REAL ESTATE
R ES	300 004	15:30	T T	31	PRIN OF REAL ESTATE
R ES	454 001	9:00	M W F	25	REAL ESTATE FINANCE
R ES	554 001	9:00	M W F	5	REAL ESTATE FINANCE

SCHEMATIC OF DEPARTMENTAL COURSE SCHEDULES -- COURSE COUNTS FROM THE SPRING'82 SCHEDULE OF CLASSES
CONFORM CODE: A=ARRANGED, X=SCHEDULED, NONCONFORMING, M=CONFORMING M-W-F, T=CONFORMING T-TH

GEOLOGICAL SCIENCES

COURSE TITLE	NUMBER	STUDENT COUNT / CONFORM CODE / SECTION NUMBER								
	GEOL									
INTRO-GEOLOGY 1	101	160M100	27X101	27X102	27X103	27X104	27X105	27X106		
INTRO TO GEOLOGY 2	102	157M100	20X101	20X102	20X103	20X104	20X105	20X106	20X107	20X108
INTRO TO GEOLOGY 2	104	157M001								
OUR DYNAMIC EARTH 2	114	151M001								
OUR DYNAMIC EARTH 3	115	17T001	24M002							
GEOL DEVEL COLO & WE	153	162M010	20X011	20X012	20X013	20X014	20X015	20X016	20X017	20X018
INTRO TO MINERALOGY	301	55M100	18X101	18X102	18X103	28X104	28X105			
STRUCTURAL GEOLOGY	312	67T001	22X010	22X011	22X012					
INTRO TO STRATIGRAPH	342	76T010	19X011	19X012	19X013	19X014				
INTRO PETROLOGY	347	63X010	21X012	21X013	21X014					
GEOLOGY FOR ENGINEER	397	68T010								
FIELD GEOLOGY	411	50X801	50X802	25X802						
STRUCTURAL GEOLOGY 2	412	6M010	6X011							
GLACIAL GEOLOGY	436	43M001								
GLACIAL GEOLOGY LAB	437	10X001								
PALEO OF HIGHER VERT	448	4M001	4X010							
INTRO PHYS SOLID EAR	453	8M001								
INTRO GEOPHYS PROSPE	493	34M010	34X011							
NAT CATAS/GEOL HAZAR	495	61T001								
MIN RESOURC WORLD AF	496	49M001								
MIN RES WORLD AFF LA	497	21X001								

EXHIBIT 2